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Synchronizing baroclinic chaos in the laboratory

A. A. Castrejón-Pita & P. L. Read

Atmospheric, Oceanic & Planetary Physics, Clarendon (aacp@atm.ox.ac.uk)

Numerical and experimental studies of the synchronization of two weakly-coupled baroclinic flow systems in a rotating thermally-driven annulus are presented. Synchronization of periodic and chaotic oscillators has become an area of great interest in many fields of knowledge. However, the study of such a phenomenon in controlled laboratory experiments is still comparatively unusual, in part because of the intrinsic difficulties in measurement and experimental control. Recent investigations have found that some atmospheric phenomena, such as teleconnection patterns, can be understood in terms of chaos synchronization theory. The study of synchronization in simple experiments and simplified models can therefore provide a useful source of insight for these atmospheric phenomena and more generally in the study of climate variability. In the present study, we have thermally coupled two separate baroclinic systems in order to observe and analyze the resulting behavior in different flow regimes. Results from both modelling and experimental work will be presented. The numerical part consists of studies performed using a pair of two-layer quasi-geostrophic models of a single baroclinic wave and a zonal flow that has been modified in order to obtain a coupled system. With this model, we investigate synchronization between the systems in both periodic and chaotic regimes. Imperfect synchronization (phase slips), phase synchronization, chaos control, and oscillation quenching have been found in the numerical work. In the experimental work, we use two coupled thermally driven, rotating baroclinic annulus systems mounted on the same rotating table. The initial aim is to study the synchronization of the natural quasi-periodic amplitude vacillations of the baroclinic waves in one annulus with those evolving in the other annulus. In due course we will move on to study more complex flow regimes, such as a low-dimensional chaotic modulated amplitude vacillation.